A Biological Assessment of Sites on Careless Creek: Golden Valley County, Montana September 11, 2003

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A BIOLOGICAL ASSESSMENT OF SITES ON CARELESS CREEK: GOLDEN VALLEY COUNTY, MONTANA

September 11, 2003

A report to

The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
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by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected on September 11, 2003 from 3 sites on Careless Creek, a tributary of the Musselshell River in Golden Valley County, Montana. These sites lie within the Northwestern Great Plains ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits.

Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

In this report, 3 assessment methods are used: first, taxonomic data is translated in to 2 bioassessment indices, and metric scores in each index are summed to derive impairment classifications and use support designations. Second, a narrative interpretation, based on the author's professional judgment is given. Metric performance and taxonomic data are both applied to this analysis. Third, the model of Barbour and Stribling (1991) is applied to bioassessment and habitat assessment scores. While the interdependence of these methods is obvious, since the same data are used for all, some degree of independence is maintained throughout the analysis. Narrative interpretations are given without regard to the bioassessment index result, and without reference to habitat assessment. Since indices are summations, they can often mask evidence of impairment; the narratives attempt to expose the potential shortcomings of the indices. Similarly, graphing the association between habitat assessment scores and bioassessment scores using the model of Barbour and Stribling can provide clues to offer support or possible refutation of the conclusions of the narrative analysis.

METHODS

Samples were collected on September 11, 2003 by Montana Department of Environmental Quality (Montana DEQ) personnel. Sample designations and site locations are indicated in Table 1 and on Figure 1. The site selection and sampling method employed were those recommended in the Montana DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1. Sample designations and locations. Sites are listed in upstream-to-downstream order. Careless Creek, September 11, 2003.

Site ID	Station ID	Activity ID	Location Description	Collection Date	Latitude	Longitude
CRLS 3	M24CRLSC03	03-L526-M	Careless Creek upstream of Deadmans Basin Reservoir	9-11-2003	46°-22'-25"	109°-17'-28"
CRLS 2	M24CRLSC02	03-L525-M	Careless Creek downstream of Deadmans Basin Reservoir diversion return	9-11-2003	46°-22'-17"	103°-16'-52"
CRLS 1	M24CRLSC01	03-L524-M	Careless Creek near mouth	9-11-2003	46°-18'-30"	109°-11'-10"

Table 2. Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis, 1998).

METRICS	**SCORES**			
	3	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 - 80	80 – 95	>95
% EPT	>50	50 - 30	30 - 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 - 5	3 - 4	<3
% Multivoltine	<40	40 – 60	60 – 80	>80

Figure 1. Approximate sampling locations. Careless Creek, July 2003.

Two bioassessment indices were employed in evaluating the data. First, the metric battery recommended in the Montana DEQ standard operating procedures (Bukantis 1998) was used. Metrics and scoring criteria for this method are given in Table 2. These metrics should be considered provisional, since correlative relationships between them and meaningful measures of habitat condition and water quality have not been evaluated. Assurance of the validity of associations between meaningful habitat measures and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources of water quality degradation and habitat disturbance. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of disturbance. The benthic assemblages of the Plains ecoregions, and the performance of these bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative. To facilitate scoring, metric values were transformed into a non-dimensional scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event.

Recently, multimetric bioassessment indices using aquatic invertebrates were developed by Bramblett et al. (2002) for streams of the Plains ecoregions of Montana. These indices were evaluated for responsiveness to anthropogenic disturbances, lack of responsiveness to natural factors, and temporal stability. Although the indices probably need further refinement and have not yet been accepted for standard bioassessment use by the State, metric values, scores, and assessments using the appropriate index are given here in Table 5. To allow for comparison with the Montana DEQ standard procedure, Figure 1 pairs scores from each method with each Plains stream site.

For both bioassessment methods, total scores were expressed as the percent of the maximum possible score and these were converted into use support classifications. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

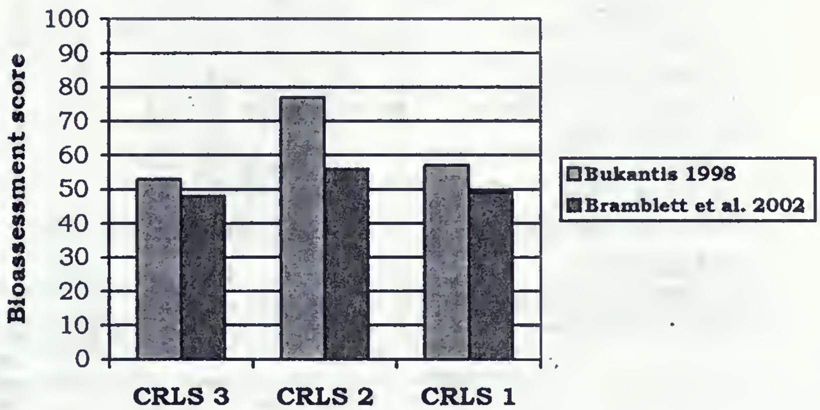
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Bioassessment

Table 4 itemizes each metric in the Montana DEQ battery (Bukantis 1998) and shows individual metric scores for each site. Table 5 similarly shows the metrics and scores for the revised Plains battery (Bramblett et al. 2002). Figure 2 compares total bioassessment scores for each of the 3 Careless Creek sites and also compares the results of the 2 bioassessment methods. The methods gave differing results when applied to these data, but both methods ranked the biotic integrity of the 3 sites in the same order. When the Montana DEQ battery (Bukantis 1998) was used to calculate scores, all 3 sites appeared slightly impaired. The uppermost (CRLS 3) and lowermost (CRLS 1) sites partly supported designated uses, and the site below Deadmans Reservoir (CRLS 2) fully supported uses. When the revised Plains index (Bramblett et al. 2002) was used, the uppermost site (CRLS 3) appeared moderately impaired, while the site below Deadmans Reservoir (CRLS 2) scored as slightly impaired. The lowermost site (CRLS 1) was moderately impaired. All 3 sites were partially supportive of designated uses.

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score). the Montana Plains ecoregions reference (Bukantis 1998) was used to calculate scores represented by gray bars, and a revised Plains battery (Bramblett et al. 2002) was used to calculate scores represented by green bars. Careless Creek, September 11, 2003.



Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

The lack of rheophilic taxa at the uppermost site on Careless Creek (CRLS 3) suggests that lentic flow conditions characterized the site. Tolerant taxa dominated the sampled assemblage; the biotic index value (7.28) was higher that expected for a Plains stream. Only 3 mayfly taxa were collected, and among these only *Caenis* sp. was abundant. Six hemoglobin-bearing taxa were present in the sample; among them were the midges *Cryptochironomus* sp.,

Table 4. Bioassessment metrics and scores for 3 sites on Careless Creek. Site locations are given in Table 1. Montana Plains ecoregions reference (Bukantis 1998).

	SITES		
METRIC VALUES	**CRLS 3**	**CRLS 2**	**CRLS 1**
Taxa richness	21	24	15
EPT richness	3	9	10
Biotic Index	7.28	5.41	3.78
% dominant taxon	43.17	30.16	69.07
% collectors	79.50	63.93	92.49
% EPT	45.03	55.08	95.08
Shannon diversity	1.29	2.08	0.98
% Scrapers + shredders	4.66	27.21	3.60
# Predator taxa	7	7	4
% Multivoltine	8.39	37.05	2.10
METRIC SCORES			
Taxa richness	2	2	1
EPT richness	1	3	3
Biotic Index	0	2	3
% dominant taxon	2	2	0
% collectors	2	2	1
% EPT	2	3	3
Shannon diversity	0	1	0
% Shredders + scrapers	1	2	1
# Predator taxa	3	3	2
% Multivoltine	3	3	3
TOTAL SCORE	16	23	17
PERCENT OF MAXIMUM	**53.33**	**76.66**	**56.66**
IMPAIRMENT CLASSIFICATION[1]	**SLI**	**SLI**	**SLI**
USE SUPPORT[1]	**PART**	**FULL**	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria.

Endochironomus sp., and *Procladius* sp. Hypoxic substrates are suggested. Nutrient enrichment and warm water temperatures seem to be indicated by these findings.

Both "clinger" taxa and caddisfly taxa were profoundly lacking from the assemblage, implying soft substrates. Instream habitat complexity may have been enhanced by the presence of macrophytes. Larval odonates (*Enallagma* sp.) are associated with emergent plants. Single individuals of only 2 semivoltine taxa were collected, and both of these (*Nebrioporus* sp. and *Laccophilus* sp.) are adept colonizers; periodic dewatering of the sampled site cannot be ruled out. The functional composition of the assemblage was overwhelmed by collectors. This finding is consistent with lentic conditions and nutrient enrichment.

Rheophilic taxa were abundant at the Careless Creek site below the Deadmans Basin Reservoir diversion return channel (CRLS 2); these included the caddisfly *Cheumatopsyche* sp. and the mayfly *Stenonema* sp. The biotic index value (5.41) was only slightly higher than

Table 5. Bioassessment metrics and scores for the uppermost site on Careless Creek. Site locations are given in Table 1. The revised Montana Plains bioassessment index (Bramblett et al. 2002) for pool sites was used.

	SITE
	CRLS 3
METRIC VALUES	
Ephemeroptera richness	3
Trichoptera richness	0
% EPT	45.03
% non-insect	34.47
Filterer richness	2
Univoltine richness	8
% supertolerant	37.58
METRIC SCORES	
Ephemeroptera richness	50.00
Trichoptera richness	0.00
% EPT	100.00
% non-insect	56.75
Filterer richness	50.00
Univoltine richness	44.44
% supertolerant	33.00
TOTAL SCORE (% of maximum)	**47.74**
IMPAIRMENT CLASSIFICATION[1]	**MOD**
USE SUPPORT[1]	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

expected for a Plains stream, and the mayfly fauna was rich (6 taxa). These findings suggest that water quality was relatively good at this site, and that thermal conditions were not extreme.

Collection at this site produced the most diverse assemblage among the Careless Creek sites studied. Instream habitats were diverse enough to support at least 24 taxa here. Eight "clinger" taxa suggest that some clean stony substrates were available. The psammophilic chironomid *Pseudochironomus* sp. was found here, indicating that sand comprised some of the substrate. Hemoglobin-bearers were not prevalent in the assemblage. Both of the semivoltine taxa taken in the sample represent mobile, colonizing taxa; periodic dewatering or thermal challenges cannot be ruled out. The functional composition of the assemblage included diverse elements. The abundance of shredders (especially *Cricotopus (Cricotopus)* spp.) was notable, and suggests riparian inputs of large organic material or abundant macrophytes.

The Careless Creek site near the mouth (CRLS 1) yielded the least diverse sample of any site studied; only 15 taxa were collected here. The sample was overwhelmed by the mayfly *Tricorythodes* sp. (69% of sampled animals). The large numbers of this animal suggest slow-

Table 6. Bioassessment metrics and scores for 2 sites on Careless Creek. Site locations are given in Table 1. The revised Montana Plains bioassessment index (Bramblett et al. 2002) for riffle sites was used.

	SITES	
	CRLS 2	CRLS 1
METRIC VALUES		
EPT richness	9	10
Percent EPT	55.08	95.8
Percent oligochaetes and leeches	0.66	0
Percent 2 dominants	54.1	84.38
Filterer richness	3	2
Percent intolerant	4.59	16.82
Univoltine richness	12	9
Percent clingers	60	11.71
Swimmer richness	2	1
METRIC SCORES		
EPT richness	81.82	90.91
Percent EPT	68.34	100.00
Percent oligochaetes and leeches	93.27	100.00
Percent 2 dominants	30.55	0.00
Filterer richness	50.00	33.33
Percent intolerant	8.88	32.53
Univoltine richness	70.59	52.94
Percent clingers	72.03	14.06
Swimmer richness	28.57	14.29
TOTAL SCORES (% of maximum)	**56.00**	**48.67**
IMPAIRMENT CLASSIFICATION[1]	**SLI**	**MOD**
USE SUPPORT[1]	**PART**	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

moving water, silty channel bottom, and perhaps emergent aquatic plants. The presence of some clean stony substrates is implied by the presence of a few "clingers" in 8 taxa, including the caddisflies *Hydropsyche* sp. and *Cheumatopsyche* sp. The site supported at least 6 mayfly taxa, and the biotic index value (3.78) was within expectations for a Plains stream; water quality may have been good at this site. The long-lived taxa collected here consisted of a few gomphid dragonflies and a single elmid beetle. It seems possible that the site is periodically dewatered or thermally stressed. The functional structure of the sampled assemblage was dominated by gatherers.

CONCLUSIONS

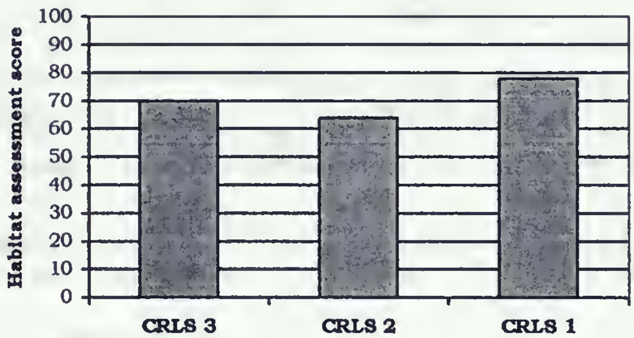
- Lentic conditions at the uppermost site on Careless Creek (CRLS 3) appear to have had the greatest influence on the bioassessment ranking of the site as the most impaired of the 3 sites studied here.

- Relatively complex instream habitats and a faunal composition that suggests good water quality characterized the site below the Deadmans Basin Reservoir return flow. The site was ranked as the least impaired by both bioassessment indices.
- Near its mouth, Careless Creek (CRLS 1) supported an assemblage with apparently less diversity than those of the other 2 sites; the sample was overwhelmed by a single mayfly taxon. However, instream habitats were probably not monotonous. Water quality was probably good at this site.

Habitat assessment[1]

Figure 3 graphically compares total habitat assessment scores recorded for the 3 sites in this study. Tables 7a and 7b show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied.

Figure 3. Total habitat assessment scores for Careless Creek sites. September 11, 2003.



Overall habitat conditions at both sampled sites on Careless Creek were judged sub-optimal. At the uppermost site (CRLS 3), channel flow status was judged marginal. Field notes indicate that riffles in the reach were dry and pools were half full at best. Long, wide, shallow pools were noted by the investigator.

Instream habitat parameters at the site below the Deadmans Basin Reservoir return were all scored optimally or sub-optimally. Streambank vegetative protection was noted to be marginal, with grasses and other annuals dominant and Russian Olive the only observed perennial. The riparian zone was severely abbreviated on both sides of the channel.

The lowermost site ranked highest among the 3 Careless Creek sites in overall habitat quality. All instream, streambank, and riparian zone parameters were judged to be in optimal or sub-optimal condition here.

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[1] In this report, habitat assessment scores are calculated to be consistent with Montana DEQ habitat assessments. That is, scores for those parameters referring to left and right bank conditions are averaged and not summed. Thus, severe degradation of streambanks, bank vegetative protection, and riparian zone widths that occur on only one side of a channel may not be clearly reflected in total scores. Summing these scores, and allowing the parameters to be weighted in accordance with summed scores, may better reflect the influence of streambank and riparian zone condition on benthic assemblages.

Table 7a. Stream and riparian habitat assessment. This Careless Creek site was assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. September 11, 2003.

		SITE
Max. possible score	**Parameter**	**CRLS 3**
20	Bottom substrate	17
20	Pool substrate char.	15
20	Pool variability	9
20	Channel alteration	18
20	Sediment deposition	15
20	Channel sinuosity	16
20	Channel flow status	6
10	Bank vegetation	8
10	Bank stability	8
10	Vegetated zone	7
170	Total	119
	Percent of maximum	**70%**
	CONDITION*	**Sub-optimal**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23% Plafkin et al. 1989.

Table 7b. Stream and riparian habitat assessment. These Careless Creek sites were assessed based upon criteria developed by Montana DEQ for streams with riffle prevalence. September 11, 2003.

		SITES	
Max. possible score	**Parameter**	**CRLS 2**	**CRLS 1**
10	Riffle development	6	9
10	Benthic substrate	6	7
20	Embeddedness	16	17
20	Channel alteration	14	18
20	Sediment deposition	14	15
20	Channel flow status	14	15
10	Bank stability	7	9
10	Bank vegetation	5	6
10	Vegetated zone	2	6
130	Total	84	102
	Percent of maximum	**64%**	**78%**
	CONDITION*	**Sub-optimal**	**Sub-optimal**

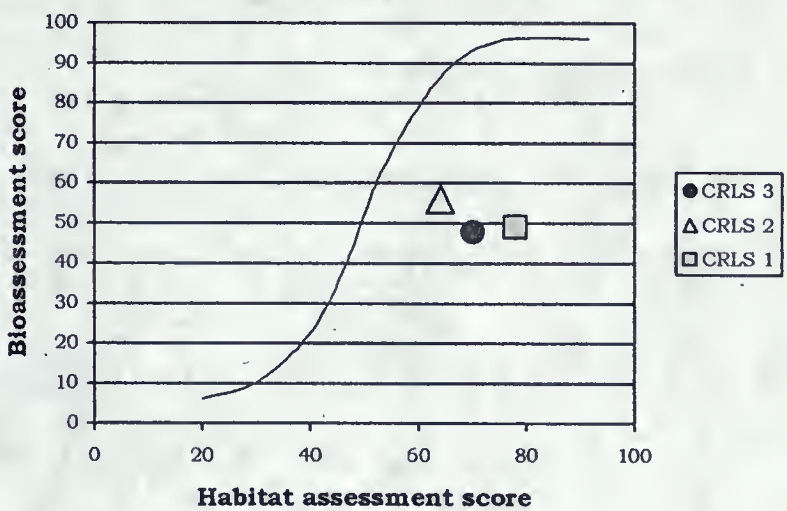
* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23% Plafkin et al. 1989.

Habitat assessment vs. bioassessment

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse, and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult.

Figure 4 is a plot of habitat assessment scores against bioassessment scores for the sampled assemblages of Careless Creek. The red line superimposed on the plot represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. Some degree of habitat degradation is hypothesized for sites located along the downward progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand quadrant of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. Symbols near the red line are sites where habitat degradation outweighs water quality perturbation in determining the integrity of biotic assemblages. The plot in Figure 3 suggests that sites on Careless Creek suffer more from water quality perturbation than from habitat degradation.

Figure 4. Total bioassessment scores plotted against habitat assessment scores for sites on Careless Creek. September 11, 2003. (Barbour and Stribling 1991).



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